

Application No. 10/630350
Amendment dated August 3, 2005
Response to telephone conversation of August 3, 2005

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Amendments to the Claims:

Please amend claim 5 and cancel claim 38.

This listing of claims will replace all prior versions, and listings of claims in the application:

Listing of Claims:

1 1. (Previously presented) A data storage device as recited in claim 10 wherein
2 the probe and storage medium positioning apparatus comprises:
3 a microfabricated positioning assembly comprising:
4 a stationary support structure;
5 a moveable support structure movably coupled to the stationary support structure
6 and moveable within a range of movement in the predefined direction with respect to the
7 stationary support structure;
8 a positionable support structure positionable in the predefined direction;
9 a stationary support structure clamp to clamp and unclamp the positionable
10 support structure to and from the stationary support structure;
11 a moveable support structure clamp to clamp and unclamp the positionable
12 support structure to and from the moveable support structure; and
13 a controller to control positioning of the positionable support structure in the
14 predefined direction within a range of positioning that is larger than the range of movement of
15 the moveable support structure by controlling (A) the stationary support structure clamp in
16 clamping and unclamping the positionable support structure to and from the stationary support
17 structure, (B) the moveable support structure clamp in clamping and unclamping the positionable
18 structure to and from the moveable support structure, and (C) the movement of the moveable
19 support structure;
20 the object being disposed on the positionable support structure so that the object is
21 positionable in the predefined direction within the range of positioning.

1 2-4. (Canceled)

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1 5. (Currently amended) A data storage device as recited in claim 1 further
2 comprising:
3 an electrostatic comb drive to electrostatically movably couple the moveable
4 structure to the stationary support structure, the electrostatic comb drive comprising:
5 a stationary comb structure connected to the stationary support structure; and
6 a moveable comb structure connected to the moveable support structure, the
7 moveable comb structure electrostatically interacting with the stationary comb structure to move
8 in the predefined direction with the moveable support structure;
9 the controller controlling the movement of the moveable structure by controlling
10 the electrostatic interaction of the stationary and moveable comb structures.

1 6. (Previously presented) A data storage device as recited in claim 1 further
2 comprising:
3 a piezoelectric drive connected between the stationary and moveable support
4 structures to movably couple the moveable support structure to the stationary support structure,
5 the piezoelectric drive expanding and contracting in the predefined direction to move the
6 moveable support structure in the predefined direction;
7 the controller controlling the movement of the moveable support structure in the
8 predefined direction by controlling the expansion and contraction of the piezoelectric drive.

1 7. (Previously presented) A data storage device as recited in claim 1 further
2 comprising:
3 a heater drive to movably couple the moveable structure to the support structure,
4 the heater drive comprising:
5 a thermally expandable and contractible structure connected between the
6 stationary and moveable support structures; and
7 heater elements disposed on the thermally expandable and contractible structure
8 to thermally expand and contract the thermally expandable and contractible structure in the
9 predefined direction to move the moveable support structure in the predefined direction;
10 the controller controlling the movement of the moveable support structure by

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11 controlling the thermal expansion and contraction of the thermally expandable and contractible
12 structure by the heater elements.

1 8-9. (Canceled)

1 10. (Original) A data storage device comprising:
2 a deformable storage medium;
3 one or more write probes each comprising:
4 a write tip comprising a highly obdurate coating capable of deforming the storage
5 medium;
6 a write tip positioning apparatus to position the write tip with respect to the
7 storage medium;
8 one or more read probes each including a conductive read tip;
9 a probe and storage medium positioning apparatus to position the read and write
10 probes with respect to each other;
11 a controller to (A) during a write mode, control the probe and storage medium
12 positioning apparatus in positioning the write probes over the storage medium, (B) during the
13 write mode, control each write tip positioning apparatus in lowering the corresponding write tip a
14 predetermined amount into the storage medium so as to cause a predetermined amount of
15 deformation in the storage medium representing data written thereto, (C) during a read mode,
16 control the probe and storage medium positioning apparatus in positioning the read probes over
17 the storage medium, and (D) during the read mode, produce and measure a tunneling current
18 between each conductive read tip and the storage medium to identify a predetermined amount of
19 deformation caused in the storage medium below the corresponding read tip during the write
20 mode so that the data written thereto is read therefrom.

1 11. (Original) A data storage device as recited in claim 10 further comprising:
2 a heater element below the storage medium;
3 the controller controlling during erase modes the heater element to heat the
4 storage medium until deformations caused in the storage medium are removed.

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12. (Original) A data storage device as recited in claim 10 further comprising:
a plurality of heater elements below the storage medium;
the controller controlling during an erase mode a selected one of the heater
elements to heat the storage medium until deformations caused in the storage medium above the
selected one of the heater elements are removed.

13. (Original) A data storage device as recited in claim 10 wherein:
each read tip further comprises:
a core material with a sharp end; and
an insulating coating over the core material except at the sharp end;
the highly obdurate coating being over the core material at the sharp end and the
insulating coating;
the controller (A) during an erase mode, controls the probe and storage medium
positioning apparatus in positioning the read probes over the storage medium, and (B) during the
erase mode, produces a current between the conductive coating and the core material of each
read tip to heat the storage medium below the corresponding read tip until a deformation caused
in the storage medium below the corresponding read tip during the write mode is removed.

14-17. (Canceled)

18. (Previously presented) A data storage device as recited in claim 10 wherein:
the positioning apparatus includes a moveable support structure to which the write
probes are connected;
the controller controlling positioning of the moveable support structure and the
storage medium with respect to each other during the write mode to control positioning of the
write probes over the storage medium;
the write tip positioning apparatus of each write probe comprising:
a cantilever connected to the moveable support structure and on which is located
the write tip of the write probe;
a cantilever mover to move the cantilever;
the controller controlling during the write mode each cantilever mover to move

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12 the corresponding cantilever a predetermined amount so as to lower the corresponding write tip
13 into the storage medium a predetermined amount to cause a predetermined amount of
14 deformation in the storage medium.

1 19. (Original) A data storage device as recited in claim 18 wherein:
2 the cantilever mover of each write probe comprises a heater element disposed on
3 the cantilever of the write probe;
4 the controller controls during the write modes each heater element to thermal
5 expandably move the corresponding cantilever a predetermined amount so as to lower the
6 corresponding write tip into the storage medium the predetermined amount to cause the
7 predetermined amount of deformation in the storage medium.

1 20. (Original) A data storage device as recited in claim 18 wherein:
2 the cantilever mover of each write probe comprises an insulating material on the
3 base support structure under the corresponding cantilever and a conductive material on the
4 insulating material so as to form a capacitor;
5 the controller controls during the write mode energy storage by each capacitor to
6 electrostatically move the corresponding cantilever a predetermined amount so as to lower the
7 corresponding write tip into the storage medium the predetermined amount to cause the
8 predetermined amount of deformation in the storage medium.

1 21. (Original) A data storage device comprising:
2 a deformable storage medium;
3 a plurality of probes each comprising:
4 a tip comprising a conductive highly obdurate coating capable of deforming the
5 storage medium;
6 a tip positioning apparatus to lower the tip;
7 a probe and storage medium positioning apparatus to position the probes over the
8 storage medium;
9 a controller to (A) during a write mode, control the probe and storage medium
10 positioning apparatus in positioning the probes over the storage medium, (B) during the write
11 modes, control each tip positioning apparatus in lowering the corresponding tip a predetermined

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12 amount into the storage medium so as to cause a predetermined amount of deformation in the
13 storage medium representing data written thereto, (C) during read modes, control the probe and
14 storage medium positioning apparatus in positioning the probes over the storage medium, (D)
15 during the read modes, control each tip positioning apparatus in lowering the corresponding tip
16 close to the storage medium, and (E) during the read mode, produce and measure a tunneling
17 current between the conductive obdurate coating of each tip and the storage medium to identify a
18 predetermined amount of deformation caused in the storage medium below the corresponding tip
19 during the write mode so that the data written thereto is read therefrom.

1 22. (Original) A data storage device as recited in claim 21 further comprising:
2 a heater element below the storage medium;
3 the controller controlling during erase modes the heater element to heat the
4 storage medium until deformations caused in the storage medium are removed.

1 23. (Original) A data storage device as recited in claim 21 further comprising:
2 a plurality of heater elements below the storage medium;
3 the controller controlling during an erase mode a selected one of the heater
4 elements to heat the storage medium until deformations caused in the storage medium above the
5 selected one of the heater elements are removed.

1 24. (Original) A data storage device as recited in claim 21 wherein:
2 each tip further comprises:
3 a core material with a sharp end; and
4 an insulating coating over the core material except at the sharp end;
5 the conductive highly obdurate coating being over the core material at the sharp
6 end and the insulating coating;
7 the controller (A) during an erase mode, controls the probe and storage medium
8 positioning apparatus in positioning the read probes over the storage medium, and (B) during the
9 erase mode, produces a current between the conductive coating and the core material of each tip
10 to heat the storage medium below the corresponding tip until a deformation caused in the storage
11 medium below the corresponding tip during the write mode is removed.

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1 25-28. (Canceled)

1 29. (Original) A data storage device as recited in claim 21 wherein:

2 the positioning apparatus includes a moveable support structure to which the
3 probes are connected;

4 the controller controlling positioning of the moveable support structure and the
5 storage medium with respect to each other during the write mode to control positioning of the
6 probes over the storage medium;

7 the tip positioning apparatus of each write probe comprising:

8 a cantilever connected to the moveable support structure and on which is located
9 the tip of the probe;

10 a cantilever mover to move the cantilever;

11 the controller controlling during the write mode each cantilever mover to move
12 the corresponding cantilever a predetermined amount so as to lower the corresponding tip into
13 the storage medium the predetermined amount to cause the predetermined amount of
14 deformation in the storage medium.

1 30. (Previously presented) A data storage device as recited in claim 29 wherein:

2 the cantilever mover of each probe comprises a heater element disposed on the
3 cantilever of the probe;

4 the controller controls during the write modes each heater element to thermal
5 expandably move the corresponding cantilever a predetermined amount so as to lower the
6 corresponding tip into the storage medium the predetermined amount to cause the predetermined
7 amount of deformation in the storage medium.

1 31. (Previously presented) A data storage device as recited in claim 29 wherein:

2 the cantilever mover of each probe comprises an insulating material on the base
3 support structure under the corresponding cantilever and a conductive material on the insulating
4 material so as to form a capacitor;

5 the controller controls during the write mode energy storage by each capacitor to
6 electrostatically move the corresponding cantilever a predetermined amount so as to lower the

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7 corresponding tip into the storage medium the predetermined amount to cause the predetermined
8 amount of deformation in the storage medium.

1 32. (Original) A data storage device comprising:
2 a storage medium alterable by light;
3 one or more light emitting write probes capable of emitting light;
4 one or more read probes capable of detecting alterations of the storage medium;
5 a positioning apparatus to position the read and write probes over the storage
6 medium;
7 a controller to (A) during a write mode, control the positioning apparatus in
8 positioning the write probes over the storage medium so that the light emitting write tips are over
9 the storage medium, (B) during the write mode, control each light emitting write probe to emit a
10 predetermined amount of light so as to cause a predetermined amount of alteration of the storage
11 medium and write data thereto, (C) during read modes, control the positioning apparatus in
12 positioning the read probes over the storage medium so that each read probe detects a
13 predetermined amount of alteration of the storage medium caused during the write mode, and
14 (D) during the read mode, measure each detected predetermined amount of alteration of the
15 storage medium so that the data written to the storage medium during the write mode is read
16 therefrom.

1 33. (Original) A data storage device as recited in claim 32 wherein:
2 each light emitting write probe includes a write tip comprising:
3 a core material with a sharp end,
4 a light emissive coating over the core material; and
5 a conductive coating over the light emissive coating;
6 the controller is coupled to the core material and the conductive coating of each
7 light emitting write tip to apply across them during the write mode a voltage of predetermined
8 amount so that the sharp end of the corresponding light emitting write tip emits a predetermined
9 amount of light so as to cause a predetermined amount of alteration of the storage medium

1 34. (Original) A data storage device as recited in claim 32 wherein:
2 each light emitting write tip comprises porous silicon;

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3 the controller is coupled to each light emitting write tip to produce during the
4 write mode a current of predetermined amount in the porous silicon of the light emitting write tip
5 so that it emits a predetermined amount of light so as to cause a predetermined amount of
6 alteration of the storage medium.

1 35. (Original) A data storage device as recited in claim 32 wherein:
2 the storage medium comprises:
3 charge storage cells each storing a charge alterable by light;
4 a conductor around the charge storage cells;
5 each read probe is conductive;
6 the controller (A) during the write mode, controlling each write probe to emit a
7 predetermined amount of light so as to cause a predetermined amount of charge in a
8 corresponding one of the charge storage cells to be leaked off so as to write data thereto, (B)
9 during the read mode, controlling the positioning apparatus in positioning each read probe over a
10 corresponding one of the charge storage cells to detect the predetermined amount of charge
11 therein leaked off during the write mode, (C) during the read mode, measure the detected
12 predetermined amounts of charges leaked off so that data written during the write mode to the
13 corresponding ones of the charge storage cells is read therefrom, and (D) during an erase mode,
14 controlling the conductor to transfer a predetermined amount of charge to the corresponding
15 charge storage cells so as to restore the charges therein leaked off during the write mode.

1 36. (Original) A data storage device as recited in claim 32 wherein:
2 the storage medium comprises:
3 charge storage cells each storing a charge alterable by light;
4 a plurality of conductors around the charge storage cells;
5 each read probe is conductive;
6 the controller (A) during the write mode, controlling each write probe to emit a
7 predetermined amount of light so as to cause a predetermined amount of charge in a
8 corresponding one of the charge storage cells to be leaked off so as to write data thereto, (B)
9 during the read mode, controlling the positioning apparatus in positioning each read probe over a
10 corresponding one of the charge storage cells to detect the predetermined amount of charge

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11 therein leaked off during the write mode, (C) during the read mode, measure the detected
12 predetermined amounts of charges leaked off so that data written during the write mode to the
13 corresponding ones of the charge storage cells is read therefrom, and (D) during an erase mode,
14 controlling a selected one of the conductors to transfer a predetermined amount of charge to the
15 corresponding charge storage cells so as to restore the charges therein leaked off during the write
16 mode.

1 37. (Original) A data storage device comprising:
2 an electrically alterable storage medium;
3 a triangular ridge support structure;
4 one or more triangular ridges on the base structure;
5 a positioning apparatus to position the triangular ridge support structure over the
6 storage medium;
7 an acoustic wave generator on one of the triangular ridge support structure and the
8 storage medium to produce surface acoustic waves thereon that propagate in a direction parallel
9 to the axial length of the triangular ridges;
10 a controller to (A) during a write mode, control the positioning apparatus in
11 positioning the triangular ridge support structure over the storage medium so that each triangular
12 ridge is over a corresponding region of the storage medium to be written, (B) during the write
13 mode, control the acoustic wave generator to produce an acoustic wave, (C) during the write
14 mode, apply at a predetermined time across each triangular ridge and the storage medium a
15 voltage pulse having a predetermined voltage and duration while the acoustic wave produced
16 during the write mode propagates so that a region of the triangular ridge above the corresponding
17 region to be written is displaced down theretoward and the corresponding region to be written is
18 electrically altered by a predetermined amount, (D) during a read mode, control the positioning
19 apparatus in positioning the triangular ridge support structure over the storage medium so that
20 each triangular ridge is over a corresponding region of the storage medium to be read, (E) during
21 the read mode, control the acoustic wave generator to produce an acoustic wave, (F) during the
22 read mode, detect with each triangular ridge at a predetermined time while the acoustic wave
23 produced during the read mode propagates so that a region of the triangular ridge above the
24 corresponding region to be read is displaced down theretoward a predetermined amount of

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- 25 electrical alteration of the corresponding region to be read, (G) during the read mode, measure
26 each detected predetermined amount of electrical alteration of the corresponding region to be
27 read so that the data written to thereto during the write mode is read therefrom.

38. (Canceled).